Title of Invention

ELECTRONIC GAS COOKTOP CONTROL WITH SIMMER SYSTEM AND METHOD THEREOF

Technical Field of Invention

This invention relates to control of gas appliances in general and more specifically to an electronically actuated gas cooktop flame proportioning control with flame sequencing simmer system.

Background Art

While easily achieved in electric cooktops, simmer temperatures have until now been complicated issues for gas cooking apparatus. Conventional gas cooktops are generally operated by using manually activated mechanical actuator knobs, with infinitely varying settings of the flow of gas by rotating associated gas proportional valves. Most often, adjustment of cooking level is achieved by comparing level indicators printed on the knob, to a fixed pointer printed on the cooktop surface, immediately surrounding the knob. With such knobs and associated infinite valves, it often becomes difficult for the user to precisely re-adjust the valve to a predetermined preferred level of BTU output and thus repeatability is rarely achieved. This effect is of an even greater concern in simmer mode of cooking where delicate food such as chocolate or sauces can be spoiled, if cooked at slightly higher temperatures than those recommended. Additionally, mechanical knobs are also usually susceptible to wear and tear and are often vulnerable to contaminants normally present in cooking areas, such as greases and moisture infiltration that generally find their way through open areas, necessary for the mechanical valve installation in the cooking surface. Spark igniters are typically used to ensure ignition of the gas and are generally activated upon rotation of the above-mentioned mechanical knobs. Most often, integrated sensors, such as flame detectors, are used to continuously monitor proper combustion of the gas. Such sensors typically provide feedback to the spark ignition module, to ensure re-ignition of the gas, should it fail to combust. However, very low flames have been proven hard to detect by such sensor types and are often a cause for spark igniters to unnecessarily generate discharges in response to false detection

incidents. Spark igniters are also known, by those in the industry, to emit powerful electromagnetic interference (EMI) that often disturbs electronic equipment working in their vicinity. Microcontrollers used in electronic controls are also known to be highly susceptible to EMI emission, and hence generally need additional protection when used in conjunction with spark igniter modules in gas cooking apparatuses. Due to their large orifice size, burners that are capable of high BTU output are usually not suitable for simmer, one of the reasons being that smaller flames have the tendency to self-extinguish in such conditions. Therefore, some cooktops have been equipped with simmer burners, featuring smaller orifice diameters and capable of delivering stable low-to-medium BTU output. This has often had the effect of reducing the number of available burners capable of high BTU output on a given cooking surface. Various methods involving flame sequencing have been used to provide gas-cooking appliances with low temperature output to provide a simmer. Sequencing the flame on and off in a timely fashion provides for an elegant solution to achieve very low BTU output from a burner also capable of high BTU output, but simmer systems of the prior art generally involve synchronized re-ignition of the gas following each flame on/off cycle, complicating even further the design of simmer controls in gas cooktops. Moreover, repeated re-ignitions of the gas during simmer mode often have the undesirable effect of continuously generating harmful electromagnetic interference. As mechanical valves are traditionally used to adjust the gas flow, additional electrically controlled "on/off" cycling solenoid valves are generally added to provide the "on/off" sequencing of the flame in simmer mode, contributing to higher system cost and reliability issues.

U.S. Pat. No. 4,376,626 to Rossi et al. (Device for the control of a sequential burner of a cooking apparatus) discloses a control device for at least one sequential burner of a cooking apparatus, comprising in combination: a geared-down synchronous motor and a drum which can be driven in rotation by this motor, an electric circuit associated with this drum, comprising at least one electric contact pressing upon the surface of the drum and at least one electrically conductive track arranged on the drum in such manner as to permit operation of the burner according to heating sequences which are variable as a function of the position of the electric contact on the drum, and means for adjusting the position of the contact in relation to the conductive track in order that

the duration of the heating sequences of the burner may be varied progressively and continuously.

U.S. Pat. No. 5,575,638 to Witham et al. (Stove burner simmer control) discloses a burner control which provides a pulsed flame sequence in response to a user's selective manipulation of an actuator through a range of response. A microcontroller-based control module switches both a burner igniter control and an electric valve for gas supply to the burner in a predetermined time sequence depending upon the actuator position within the predetermined range. Preferably, one or more of a plurality of burners on a single cooking top are controlled for pulsed sequence operation, and a single actuator for each channel, preferably in a form of a rotary knob, provides a simple user interface for utilizing the pulsed flame sequence, preferably in a low gas flow or simmer cooking range.

U.S. Pat. No. 6,116,230 to Clifford et al. discloses a gas appliance comprising a burner, a conduit, a control circuit, and a valve. The control circuit is adapted to provide a pulse-width-modulated signal to the valve, whereby the valve provides a substantially linear flow rate of fuel from a fuel source to the burner. The gas appliance of Clifford et al. employs a spark igniter.

Thus, there is a need for an electronically controlled gas cooktop appliance capable of delivering true simmer temperatures from gas burners that are also capable of high BTU output. There is also a need for an electronic gas cooktop appliance that is capable of fine, precise, and repeatable control of heating levels, provided by a direct level-dialing control, thus providing the user with a more precise selection of available and controllable temperatures. There is also a need for a gas cooktop appliance capable of assuring flame re-ignition without generating harmful electromagnetic interference. There is equally a need for a gas cooktop flame-sequencing simmer system integrating gas-flow modulation and "on/off" sequencing ability into a single gas valve. Finally, there is a need for a gas cooktop appliance integrating an electronic user touch interface for burner activation and selection of temperature settings.

Objects of the Invention

The present invention is intended to provide practical solutions to problems in the existing art, thus globally fulfilling the above-mentioned needs.

A major object of the invention is a gas cooktop appliance capable of delivering very low heat power while maintaining capability of delivering very high BTU output, in each available burner, and also capable of fine, precise and repeatable control over the entire span of cooking levels. Another object of the present invention is to provide a gas cooktop appliance with an innovative electronic control featuring a capacitive touch user interface, thus featuring a flat, smooth and sealed cooking surface. Such a capacitive touch interface facilitates the maintenance of surfaces that are generally prone to become dirty and that are also difficult to reach. A capacitive touch interface offers the additional benefit of eliminating the wear and tear associated with mechanical devices and also of preventing contaminants such as greases and moisture from reaching sensitive components internal to the cooktop apparatus.

Another object is an electronic control capable of handling simultaneously both modulation of the valve(s) for metering the gas flow delivered to the burners from medium to high BTU output, and sequencing of the flame "on" and "off" at a predetermined medium level of flame, to provide efficient simmer temperatures. An additional object is to provide electronic control of a gas cooktop featuring a direct-dial keyboard-entry system and a digital visual user interface such that repeatability and precise re-selection of predetermined cooking levels is achieved. Yet another object is to provide an initial gas ignition and a flame sequencing re-ignition system that does not need to be synchronized with the flame on/off cycling during simmer cook mode and that does not generate harmful electromagnetic interference.

Summary of the Invention

The present invention relates to the field of gas cooking appliances in general and more specifically to a micro-controller-based electronic controller and simmer system for a gas cooktop appliance. In a preferred embodiment, the present invention is presented as a gas residential cooktop with controls, but it will be understood that the

teachings of the present invention are also applicable to industrial and commercial gas cooktop appliances.

Among features provided by this invention are: a capacitive touch keyboard interface, an entirely electronic control system controlling the gas flow through modulating valves; an innovative modulating valve activated through a pulse-width-modulation (PWM) port, capable of infinitely controlling the flow of gas while also providing for an "off" position, the electrical modulating valve therefore eliminating the need for an additional in-line solenoid valve to sequence the flame "on" and "off" during simmer operation; and ceramic hot-surface igniter(s) controlled and monitored by the electronic control system, capable of constant gas re-ignition without generation of electromagnetic interference.

Natural or propane gas is selectively provided to each individual burner, through the use of electrically actuated modulating valves, thus eliminating the need for mechanical valves and actuator knobs protruding through the user console and facilitating the maintenance of such surfaces. Ignition of the gas is monitored through temperature sensing, and ceramic hot-surface igniters are also monitored through current sensing. Safety features such as main in-line valve closure and de-energizing of the igniters are supported in the event that a fault condition occurs. Features such as visual and audible alarms are also generated, providing the user with positive indications of serious error conditions.

Brief Description of the Drawings

FIG. 1 is a basic block diagram of a cooktop system made in accordance with the invention.

FIG. 2 is an example of one of many possible user interfaces, to be used in conjunction with the present invention.

FIGS. 3a and 3b together show a flowchart of control software for a preferred embodiment of the invention.

Detailed Description of Preferred Embodiments

FIG. 1 is a basic block diagram of a cooktop system made in accordance with this invention. The cooktop shown in FIG. 1 has one or more gas burner(s) **114** placed on a ceramic glass panel **109**; one electronically controlled in-line safety gas valve **112**; one or more electronically controlled in-line modulating valve(s) **113**; a gas line conduit **123** to conduct gas from the main gas supply to the burner(s) under control through the in-line valves; a user interface panel **110** preferably placed in registry with a silk-screened portion of a ceramic glass panel **109**; one or more temperature sensor(s) **118**; one or more hot-surface igniter(s) **117**; and a controller **111** operative to control each of the gas valves in accordance with the user's selection entered at the user interface, the apparatus being controlled by a suitably programmed microcontroller **101**.

The user interface panel **110**, placed in registry with a silk-screened portion of a ceramic glass panel **109**, preferably further includes one or more visual indicator(s) **116**, such as seven-segment LED displays, discrete LED displays, bar-graph LED displays, LCD displays, and vacuum fluorescent displays, for displaying information **120** concerning the status of the cooktop to the user; an audible annunciator **125** such as an external drive or built-in drive piezo-acoustic element, magnetic transducer or Mylar speaker, used to provide audible indication **124** that a touch key is selected and also to provide for an audible alarm whenever a system error is detected; and an array of capacitance sensitive keypads **115**, each one having a capacitive field **119**, produced, detected and analyzed by a capacitive-keyboard decoding interface module **102**, and capable of electrically reacting to a human hand or finger **121**, placed in proximity with any one capacitive field **119** associated with one of the capacitance sensitive keypads **115**.

The microcontroller-based control **111** comprises an array of modules, dedicated to the driving and monitoring of the various elements of the system, controlled by the microcontroller **101**.

The display elements of the visual indicators **116** are driven by a display-power-driver module **103** preferably comprising serial output shift registers (integrated circuits),

multiple channels of source-driver integrated circuits, multiple channels of sink-driver integrated circuits, and may also include driver circuits using discrete transistors.

A power module **126** consisting of discrete transistor circuitry drives the audible interface **125**. Power module may be unnecessary if the audible interface is made with one or more built-in drive acoustic annunciators.

A valve-power driving module includes a power relay or a triac module **107** for driving main safety valve **112** and a Darlington array integrated circuit or an array of discrete transistors **108** for driving the modulating valve(s) **113**.

An igniter-power driving module **105** is also provided and includes a power relay or a triac module for driving one or more ceramic hot-surface igniter(s) **117**. A current sensor module **104** is also provided for monitoring the current flowing through the hot-surface igniter(s) **117**.

Appropriate amplification module **106** is provided to deliver reliable temperature sensor data, at the proper voltage span, to an analog-to-digital input port of microcontroller **101**. Amplification may not be needed for some sensors, and thus module **106** may also be a simple voltage divider circuitry, e.g., if the temperature sensor used is a thermistor.

A sine-to-square-wave converter input module **127** is preferably included in the microcontroller-based control **111** to provide the microcontroller **101** with a reliable time base for proper timing of "on/off" flame sequencing periods, during simmer mode. The sine-to-square wave converter input module **127** may consist of a diode rectifying input circuitry, tapping a portion of the conventional AC supply voltage and feeding a transistor based circuit. That circuit, connected to a pull-up resistor, provides as an output a square wave representative of the 50 Hz or 60Hz signal carried by the AC voltage supply line.

Additionally, the microcontroller-based control **111** preferably includes a capacitive-keyboard decoding interface module **102** with a serial or parallel communication interface, capable of detecting and analyzing a user touch condition. The capacitive-keyboard decoding module preferably includes: a capacitive matrix decoder integrated circuit with a serial or parallel communication interface, a portion of the

ceramic glass panel **109** (preferably silk-screened) used to provide for a user touch interface, and an array of capacitive sensing keypads **115** placed in registry with the user touch interface portion of the ceramic glass panel **109**. Key sensitivity may be made individually trimmable for adaptation to key size, key shape, and key location on the user interface keyboard. Capacitive sensing for the keyboard interface may be done as described in U.S. Pat. No. 5,730,165 to Philipp, the entire disclosure of which is hereby incorporated by reference. In U.S. Pat. No. 5,730,165, a capacitive field sensor employs a single coupling plate to detect a change in capacitance to ground. The apparatus comprises a circuit for charging a sensing electrode and a switching element acting to remove charge from the sensing electrode and to transfer it to a charge detection circuit.

A suitable capacitive-keyboard decoding interface **102** is the model QM1, available from Quantum Research Group Ltd. of Southampton, England and Pittsburgh, PA, or preferably the models QT60320 and QT 60321 Matrix Scan IC's available from that company. The QT60320 family of Matrix Scan IC's is a family of capacitive-keyboard decoding interfaces, based on the Philipp invention mentioned above, utilizing dual coupling capacitive plate sensors, disposed in a key matrix configuration.

The microcontroller-based control **111** also preferably includes a microcontroller integrated circuit **101** having integrated features, as per the following list:

a) a bi-directional serial communication port for interfacing with a capacitive-keyboard decoder integrated circuit;

b) a serial peripheral interface port for interfacing with display interface circuitry;

c) a pulse-width-modulation (PWM) output port for controlling gas modulating valves;

d) an input port for 60 Hz signal detection;

e) an output port for controlling a main gas solenoid safety valve;

f) an output port for interfacing with an audible annunciator;

g) an analog-to-digital converter input port for temperature monitoring;

h) an output port for controlling a gas igniter module; and

i) an analog-to-digital converter input port for monitoring gas igniter current.

Those skilled in the art will recognize that multiple ports of any of the types listed may be provided.

The valve portion of the system preferably includes an in-line gas valve assembly having a single main in-line solenoid safety valve **112**, commonly found in the industry and an in-line modulating valve **113** for each burner. One suitable modulating valve is disclosed in U.S. Pat. No. 5,458,294 to Zachary et al., in which a variable orifice solenoid has a plurality of positions, and the positions are controlled by the application of a voltage signal to the modulating valve. The entire disclosure of U.S. Pat. No. 5,458,294 to Zachary et al. is incorporated herein by reference, as is the entire disclosure of U.S. Pat. No. 6,116,230 to Clifford et al., mentioned above.

U.S. Pat. No. 5,458,294 discloses an apparatus for accurately controlling gas fuel flow to a combustion device to control gas flow to a burner of the combustion device. A variable orifice solenoid-operated valve serves as a control element. The valve includes a poppet having a fixed control surface at an end received in an insert element having a variable control surface. The poppet has a plurality of positions within the insert element, including a full open position and a full closed position. Maximum fuel flow is measured in the full open position and minimum fuel flow is measured in the full closed position. Intermediate partially open positions are adjustable by a signal of an electronic controller connected to the solenoid valve operating as a function of actual and desired temperature of the combustion device. If desired, the fixed control surface can contact the variable control surface at some point as the fixed control surface moves into the insert, to completely seal the valve and shut off the flow of gas to the burner means.

The flame ignition portion of the system preferably includes a resistive hot-surface igniter **117**, preferably fixed to the burner base **128**, capable of producing a temperature of 1350°C in a time-to-design-temperature equal to or less than 3 seconds. U.S. Pat. No. 5,892,201 to Croucher et al., discloses a ceramic igniter, comprising: (a) a pair of electrically conductive portions, each portion having a first end, (b) a hot zone disposed between and in electrical connection with each of the first ends of the electrically conductive portions, the hot zone having an electrical path length of less than 0.5 cm, and (c) an electrically non-conductive heat sink material

contacting the hot zone. The entire disclosure of U.S. Pat. No. 5,892,201 to Croucher et al. is incorporated herein by reference. One suitable resistive ceramic hot-surface igniter is the Norton Igniter model No. M-401 manufactured by Saint-Gobain Industrial Ceramics Inc. of Milford, NH.

Additionally, the invention provides for one or more temperature sensor(s) **118**, each one fixed to the burner base **128** and directed at the flame area of the burner to detect a flame, thus monitoring proper ignition of the gas delivered to the burner **114** by the modulating valve(s) **113**. The temperature sensor may be of any suitable type, such as: thermistors, thermocouples, or infrared temperature sensors.

Operation

A continuous flame modulation mode of operation, described below, is used for the portion of the total span of gas output levels that can be safely modulated by the modulating valve, where the flame is continuously present and not sequenced "on" and "off" by the controller. This continuous flame modulation mode is associated with cooking levels ranging from medium-low to high BTU output. Furthermore, medium-low level of flame is defined here as being the lowest level of flame that can be safely maintained without self-extinguishing, can be safely ignited by a ceramic hot-surface igniter, and can be easily sensed by the flame detector, for any particular burner orifice size.

In continuous-flame-modulation mode of operation the microcontroller **101** first sends a signal to the power-driving portion **107** of the controller, driving the safety valve **112** "on" to permit the gas entering the system **122** to reach the in-line modulating valve(s) **113**, then the microcontroller **101** sends a pulse-width-modulation signal to the power-driving portion **108** of the controller **111** driving the modulating valve **113**, to proportionally modulate the valve opening size to the desired gas flow level, as selected by the user and, thus, to permit the gas to reach the burner. Hence, this mode of operation adjusts the flame height to any desired level of BTU output ranging from medium-low to high BTU output. Furthermore, in this particular mode of operation, the hot-surface igniter **117** is powered only during the first phase of the continuous-flame modulation mode of operation. Ignition is provided and maintained from the time that the gas is permitted to reach the burner, until a flame is detected by the

appropriate temperature sensor **118** associated with the controlled burner. Ignition process can also be aborted if one of the following error conditions occurs: no hot-surface igniter current is sensed, and/or flame is not detected for a predetermined period of time. In any of these error condition cases, the controller **111** automatically turns off the safety valve **112**, the hot-surface igniter **117**, and the modulating valve **113** corresponding to the faulty burner. Then, visual and audible signals are generated to alert the user of the faulty condition.

Simmer mode of operation is defined here as being the mode of operation used for the lowest portion of the total span of BTU output levels. In simmer mode of operation, the microcontroller **101** first sends a signal to the power-driving portion **107** of the controller, driving the safety valve **112** "on", to permit the gas entering the system **122** to reach the in-line modulating valve(s) **113**. Then, the microcontroller **101** sends a predetermined pulse-width-modulation signal to the power-driving portion **108** of the controller **111** driving the modulating valve **113**, to proportionally modulate the valve opening size to a predetermined level of gas flow, and, thus, to permit the gas to reach the burner. In simmer mode of operation, the pulse-width-modulation (PWM) output level is set to provide a predetermined medium-low height level of flame that can safely be maintained without self-extinguishing, can safely be ignited by the ceramic hot-surface igniter, and can easily be sensed by the flame detector, for any particular burner orifice size. In that particular mode of operation the pulse-width-modulation output, which drives the modulating valve associated with the burner working in simmer mode, is continuously being sequenced "on" and "off" by the microcontroller **101**. A time-based sequencer, ruled by appropriate software program and 60Hz detection module **127**, is activated, toggling the PWM output driving the modulating valve, and thus turning the flame "on" and "off" in a timely fashion. During the "off" portion of the sequencing, while no PWM signal is provided to the modulating valve, the valve reverts to its "off" position, sealing the opening and thus preventing the gas from reaching the gas burner under simmer mode of operation. During the "on" time portion of the sequencing, the PWM output is set to the medium-low level of BTU output, providing the safest low level of flame that can be ignited, maintained, and sensed by the temperature sensor. The "on" and "off" periods are produced to correspond to a desired simmer level as selected by the user. As an example of this,

for a particular output level, as selected by the user; "on" time, when the flame is present, can be equal to 1 second, and "off" time, when the flame is not present, can be equal to 7 seconds, to produce a 1 over 8 or 1:8 ratio of BTU output in relation to an hypothetical constant flame produced at the same predetermined flame height level. Additionally, during that particular mode of operation, the hot-surface igniter **117** is continuously powered by the igniter power module **105**, and constantly monitored by the igniter-current sensor module **104** to provide for an instantaneous ignition process, bypassing the time-to-design-temperature period. Furthermore, the temperature sensor output is read during each "on" portion of the flame sequencing activities. Ignition is thus provided and maintained until the user selects a burner powering level other than those provided within the span of simmer mode of operation, and can also be aborted if one of the following error condition occurs: no hot-surface igniter current is sensed and/or flame is not detected during the "on" periods of the sequencing cycles. In any of these error condition cases, the controller **111** automatically turns off the safety valve **112**, the hot-surface igniter **117**, and the modulation valve **113**. Then, visual and audible signals are generated to alert the user of the faulty condition.

Total span of BTU output can range from very low to very high and have an infinite number of steps from which many can operate in simmer mode of operation and many others in the continuous flame modulation mode of operation. For example, a particular control could arbitrarily offer 44 levels of BTU output, from which the lowest fourteen levels could be operating in a simmer mode of operation and the remaining 30 levels could be modulated in a continuous flame modulation mode of operation. The above-mentioned example is given here only as one possible embodiment of the present invention and does not intend to constitute a limitation to the present invention. One of ordinary skill in the art would readily perceive that the total number of possible cooking-level steps, as well as the portion of these steps predetermined to work either in the simmer mode or in the continuous flame modulation mode of operation, are readily defined by appropriate software programming alone. Control software programming is described next.

Control Software

FIGS. 3a and 3b together show a flowchart of control software for a preferred embodiment of the invention, using conventional flowchart symbols. Table I below shows the steps used in the control software illustrated in FIGS. 3a and 3b together.

Step	Function performed
300	Start burner subroutine
301	Test: Is at least one burner active?
302	Shut safety valve OFF
303	Scan keyboard for user input
304	Test: Is a burner OFF key selected?
305	Shut igniter OFF; stop PWM output; clear burner display
306	Go to main routine
307	Test: Is a burner ON key selected?
308	Show "0" in selected burner display; enter selected burner program mode
308.1	Test: Is there a burner in program mode?
309	Test: Is a burner BTU level selected?
310	Is the selected BTU level a simmer level?
311	Energize the hot surface igniter, etc. (Simmer mode -- see description)
312	Energize the hot surface igniter, etc. (Continuous flame modulation mode -- see description)
313	Test: Is current of the selected hot surface igniter sensed?
314	Test: Is current of the selected hot surface igniter sensed?
315	Test: Is flame sensed at the selected burners?
315.1	Loop flame sensing for predetermined period of time
316	Test: Is flame sensed at the selected burners?
316.1	Loop flame sensing for predetermined period of time
317	Display appropriate error code; sound audible alarm
318	De-energize appropriate hot surface igniter

TABLE I. Control software process steps

It can be seen in FIGS. 3a and 3b that if no burner is activated **301**, the safety valve of the gas system is turned "off" **302**. As illustrated in the flow chart of FIGS. 3a and 3b, the keyboard is periodically scanned for user input **303** and, depending on the type of key detected as touched by the capacitive-keyboard-decoding interface, a specific number of steps are consequentially performed by the microcontroller as dictated by the control software. For instance, if a burner "Off" key is touched **304**, the microcontroller will then shut the appropriate igniter "off", stop the PWM output to the appropriate modulating valve, clear the appropriate burner display **305** and finally revert to the main routine of the control software **306**. If a burner "On" key is detected **307**, the software will place the appropriate burner in programming mode and notify the user of that condition using of the appropriate display **308**. If a burner level key is selected **309**, the software verifies **310**, through the use of a software table, whether the selected BTU level belongs to the class of BTU output dedicated to simmer mode or to continuous-flame-modulation mode of operation, and chooses the appropriate mode accordingly. Although the two modes of operation adopt different behaviors **311** and **312**, in both cases current flowing through the igniters **313** and **314** and also flame ignition **315** and **316** are monitored for proper operation.

If no current flows through the igniters while activated and/or no flame is sensed while gas is conducted to the burner under control, then visual and audible alarms are generated **317**, and the faulty burner is deactivated by stopping appropriate PWM output, shutting off the appropriate igniter and clearing the appropriate burner display **305**.

In simmer mode of operation shown by the series of actions identified by reference numeral **311**, i.e., when a simmer level of BTU output is selected by the user, the microcontroller energizes the hot surface igniter, energizes the main solenoid valve, outputs a predetermined PWM level to the appropriate modulating valve, sets the PWM output sequencer to selected BTU output level, shows the selected burner level in the burner display and leaves the igniter continuously "on" during the entire simmer operation.

In continuous-flame-modulation mode of operation, shown by the series of actions identified by reference numeral **312**, i.e., when a level of BTU output other than

simmer level is selected by the user, the microcontroller then energizes the hot surface igniter, energizes the main solenoid valve, outputs the selected PWM level to the appropriate modulating valve, shows the selected burner level in the burner display and further de-energizes the hot surface igniter once the ignition of the flame is achieved **318**.

Use of the Invention

To use the invention, a user touches desired control keys on the cooktop keyboard similar to the one illustrated in FIG. 2. For example, the user may touch a POWER key **201** to energize the keyboard and enable the controller. The user may then touch the ON key **202** of a particular burner, corresponding to a particular position on the keyboard layout, to turn a specific gas burner on. The user may touch arrow keys **203** to raise or lower the gas power level for the selected burner and get a visual indication of the newly selected power level, through the visual interface **204**. If a "slider" control is provided on the keyboard layout, the user can move a finger along the slider control to control the heat level of a particular burner. The user may directly touch any one of the POWER level number **205** or "L" **206** for low or "H" **207** for high. The user may touch the "off" key **208** of a particular burner to turn it off or touch the POWER key **201** to turn every active burner off. The particular keyboard layout embodiment depicted in FIG. 2 is meant to be representative of a type of touch-sensitive keyboard layout suitable for a cooktop. Preferably, the keyboard layout should, by the use of numerals, symbols, and other indicia, convey to the user the various control functions available, in a manner that is as clear and intuitive as possible. The person of ordinary skill in the art of appliances will recognize that many variations of keyboard layouts with correspondingly programmed functions may be made that are suitable for various uses of gas or hybrid gas/electric cooktops.

Industrial Applicability

The invention is useful in domestic and commercial cooking, providing an electronically controlled gas cooktop with multiple heating modes, including precisely controlled simmering and safety features.

Although specific embodiments of the present invention have been illustrated in the accompanying drawings and described in the foregoing detailed description, it will be

understood that the invention is not limited to the particular embodiments described herein, but is capable of numerous rearrangements, modifications, and substitutions without departing from the scope of the invention. One skilled in the art can easily ascertain the essential characteristics of this invention, and without departing from the spirit and scope thereof, can make various changes and modifications of the invention to adapt it to various usages and conditions.

What is claimed is: